

# PATENT SPECIFICATION

DRAWINGS ATTACHED

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## COMPLETE SPECIFICATION

### Improvements in and relating to Rotary Piston Internal Combustion Engines

We, MASCHINENFABRIK AUGSBURG-NÜRNBERG A.G. of Nürnberg, Germany, a Body Corporate organised under the Laws of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THE PRESENT INVENTION relates to internal combustion engines of the rotary or gyratory piston type.

The present invention is based on the problem inherent in controlling the mixture-forming and combustion sequence in engines of the rotary or gyratory piston type to obtain high thermal efficiency. In seeking to resolve said problem, it is necessary to take into account the peculiarities of the rotary piston engine, which for example exclude the possibility of raising the compression ratio at will without thereby unfavourably affecting other important constructional factors, such as swept volume or overall size, for example. It is of special interest moreover to restrict the magnitude of peak pressure, in order to allow bearing loads to be limited to permissible values, since the piston area is large in relation to the working volume. In order to improve the thermal efficiency, it is necessary on the one hand to increase the compression ratio, and on the other hand to regulate output at identical rotational speed in such manner, that the excess of air increases under part load, the mixture ratio thereby being weakened, whereas in the case of the Otto cycle for example, the mixture ratio remains practically constant or may be varied within narrow limits only in order to remain within the ignition range of the mixture.

Solutions of the kind last alluded to have become known in the form of charge stratification in engines of the reciprocating piston type. Their effectiveness in respect of part load

consumption is operative for any compression ratio, irrespective of whether the latter is high or low. The most favourable consumption figures are theoretically obtained for compression ratios corresponding approximately to those of reciprocating piston engines of the Diesel type designed to run at high speed. In the case of rotary piston type engines however, it is frequently of interest in view of constructional desiderata, not to utilise too high a compression and thus in certain circumstances also to renounce the utilisation of spontaneous combustion, without however intending to forfeit the advantage of precise mixture control.

In Diesel engines of the reciprocating piston type it is known what difficulties are encountered in ensuring a combustion sequence which after the start of ignition initially allows the release of relatively small quantities of heat and thus assures low pressure rise speeds, whereas after the start of expansion, it allows the quantity of heat released per degree of crank rotation to increase up to a maximum which as far as possible coincides with the cessation of combustion. A combustion sequence of just this nature is what is required in order to cope with the constructional peculiarities of the rotary piston type engine. The present invention indicates a way of resolving this problem, with the purpose of avoiding the spontaneous compression-ignition reactions which occur when liquid fuel is by injection atomised in hot compressed air, and of assuring a gradual intermingling of vaporised fuel with the air intended to sustain combustion. Combustion space surfaces whereof the temperature is adapted to the particular nature of the fuel utilised were found to be particularly advantageous in securing rapid evaporation. The most favourable temperature is 340° Centigrade for fuels whereof the molecular composition is approximately

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represented by the formula  $C_{16}H_{31}$ . Temperatures of this magnitude are encountered at the piston surface in an engine of the rotary piston type. According to the present invention it is proposed to equip said piston with passages separated from the combustion spacer by permeable barriers, for instance porous or perforated plates, whereof the side facing away from the combustion space may be coated with fuel. In doing so, the fuel is on the one hand distributed owing to the action of peripheral acceleration imparted to it by the rotation of the piston, and on the other hand by means of centrifugal forces generated by the rotation of the piston which essentially tend to fling the liquid fuel outwards radially towards the casing. The porous plate serves the purpose of holding the liquid fuel back against centrifugal forces and of ensuring that only the hot vapours forming in said plate, which by virtue of its porousness may possess a very large surface, can issue therefrom. Since two combustion spaces are provided moreover during the rotation of the rotary piston, whereof the leading one increases in volume from nought to a maximum whereas the trailing one simultaneously decreases in volume from a maximum to nought, and since the two spaces referred to are essentially separated from each other by the constriction in the trochoid, a violent movement of air occurs at the constriction point during transference from the one combustion space to the other, which movement owing to the lack of other connecting passages is forced to exploit the permeability of the porous plate, the traversal of the air through the latter causing intensive evaporation and admixture, which moreover travels with the rotation of the piston. In this sense, the porous plate constitutes a very effective surface carburettor incorporated in the piston, which produces the required gradual evaporation and mixing of the fuel. It is advisable to make provision for means of ignition, particularly in order to assure reliable starting from cold, as well as to avoid having to utilise too high a compression ratio. Said means of ignition may consist of an electrical igniting spark, or alternately of a hot point of which the effectiveness is enhanced by catalytic means.

In this connection, the material and the nature of the porous plate, which may be of a porous coarsely sintered material, are of considerable advantage in ensuring satisfactory combustion. The initial flame reaction of the diesel engine ignition initiates compression-ignition and must operate reliably even when relatively low compression pressures and resultant low compression temperatures are used, more particularly in the case of high-speed diesel engines, and the permeable barrier is therefore provided with catalytically active substances which accelerate the initial flame reaction and which are not consumed,

as is known. Chromium oxide may for instance be used; if a porous ceramic plate is employed the chromium oxide may be added in powder form during the manufacture of the porous material. In the case of a plate with a number of holes, chromium oxide could for instance be for instance catalytically applied to one or more locally distributed areas on the plate. Lastly, it is also possible to make a plate having a plurality of holes and consisting of a material which contains catalytically active constituents. In this way the reactive phenomena can be influenced in a favourable manner in respect of reaction products as well as of speed of reaction, thus assuring a high degree of combustion leaving small residues only.

The present invention is hereinafter to be particularly described by way of example but in no manner by way of limitation, with reference to the accompanying drawings. The figures 1 to 7 relate to a rotary piston engine of the 2 and 3 lobe type, in which the housing has two lobes and the rotor has three, but may analogously be adapted to correspond to other engines of the rotary or gyratory piston type utilising the trochoid type of construction.

Figure 1 illustrates a cross-section taken through a rotary piston engine of the 2 and 3 lobe type, said section passing through the central plane of the piston and thus also sectioning the porous plates referred to.

Figure 2 illustrates the same section through a rotary piston engine, in a later piston position.

Figure 3 illustrates the same section as figure 1, but including the illustration of a modified system for the injection of fuel behind the porous plate,

Figure 4 illustrates the same section as the preceding figures, but with a still further modified system for the injection of the fuel behind the porous plate,

Figure 5 illustrates a partial section taken through the piston along the plane containing the axis of the crankshaft at approximately equal distances from the two sealing strips concerned, and showing a passage such as specified in claim 8,

Figures 6 and 7 show the same section as figure 5, but with passages of different form,

Figure 8 shows the external appearance of one of the piston surfaces.

The numeral 1 marks the trochoid-shaped housing in figure 1. 2 designates the rotary piston rotating in said housing in essentially known manner in the direction shown by the arrow 9. The sealing strips or bars are marked with the numeral 3. 4 marks the exhaust port and 5 the inlet port of the rotary piston engine. The piston possesses three surfaces 6, 7 and 8 constituting boundaries for the combustion spaces. According to the present invention, porous plates 10 are incorporated in the piston and each cover a passage 11. This

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passage may where considered appropriate taper in cross-section in the direction opposite to the direction of rotation of the piston and may at its extremity 12 lead into the combustion space 13. The start of the passage 11 is marked 14, and a nozzle injecting in the direction aligned on the passage 11 is marked 15. This injection is preferably performed in the form of a compact jet of fuel. 17 marks the constriction on the compression side of the trochoid. 31 is the orifice of the passage 11 and 32 is the nozzle drilling of the injection nozzle 15. The combustion space opening out in the direction of rotation is marked 16 in figure 2. The arrows 18 indicate the currents of air occurring between the space 13 and the space 16, 19 and 20 designating means of ignition, and 21 a slight flattening of the plate 10 or of the piston top.

A lateral opening leading to the passage 11 beneath the plate 10 is marked 22 in figure 3. In figure 4, an opening in the plate 10 is marked 23 and a prominence intended to split the jet of fuel and projecting into the passage 11 is marked 24. The nozzle, or the nozzle bore, is indicated by the numeral 33 in figure 4. In figure 5, the passage 11 has a kidney-shaped cross-section marked 25, and the corresponding connecting openings are marked 26.

Forms of embodiment of the connecting openings and their positions are marked 27 in Figure 6 and 28 and 29 in figure 7. In figure 8, a plate secured to the piston top is marked 30. The remaining numerals in the figures correspond to each other.

From injection systems utilised on Diesel engines it is known to be customary for the nozzle bore to be conjointly with the needle disposed within an injector unit. In order to allow for the peculiarities of the rotary piston engine, it is according to the present invention to depart from this customary method of construction. The nozzle bore 32 is directly drilled into the housing 1 of the trochoid. The needle which closes off the nozzle bore 32 may now also be directly incorporated in the trochoid-shaped housing, or may as hitherto customary be disposed in a separate injector unit. This disposition confers the advantage, that the sealing strip or bar 3 slides across the nozzle bore without having to follow deviations of form caused by an injector unit screwed in from the outside.

If drillings or depressions were to be disposed in the trochoid-shaped housing 1, there would be a risk, that the gases in front and behind the sealing bar 3, which are at different pressures, would at the moment said bar slides over these drillings or depressions cause a violent movement of air, leading to damage or trouble in connection with the sealing bar or the drillings or depressions. Depending on the sequence of operation in the ad-

joining chambers, the pressure differential is equal to nought or close to nought at certain positions of the rotary piston. A position of this kind is shown in approximation in figure 1, wherein the space 13 is under compression, whereas the space 34 is under negative pressure. At this stage, the pressure differential at the sealing bar 3 passes through the value nought. It will be apparent, that this is the most favourable instant at which to allow the sealing bar 3 to run across a drilling or depression in the trochoid-shaped housing 1, since a transfer of gas does not occur at said instant.

An engine constructed in accordance with the present invention operates in the following manner:

When the piston moves in the direction of the arrow 9, the space 13 is in the condition equivalent to the compression stroke. The velocity of the sealing bar 3 nearest to the nozzle 15 in Fig. 1 is still close to its minimum at this instant. The injection out of the nozzle bore 32 which conveys the fuel in the direction towards the passage 11 starts when the opening 31 of the passage 11 comes into alignment with the nozzle bore 32. The same methods are utilised for this injection as are known for the injection of fuel in the case of Diesel or Otto engines of the reciprocating piston type. The nature of the jet and the injection pressure are adapted to operating requirements. In view of the velocity imparted to the fuel by injection under pressure, the fuel tends to run towards the extremity 12 of the passage 11. The distribution of the fuel in the direction referred to is favourably assisted by the rotation of the piston, since the piston turns in the direction shown by the arrow 9. The distribution of the fuel may also be successfully attained by fully exploiting only the inertia of the fuel, thereby allowing the injection through the nozzle 15 to be carried out at very low pressures and low injection velocities, but with a large jet cross-section. In the case of the method last referred to, the passage 11 is so to speak pushed over the fuel by the rotary motion of the piston.

As the piston continues to rotate, the fuel acquires the velocity of the piston, thereby being subjected to the action of centrifugal force. Said action forces it through the porous plate 10 causes it to vaporise therein, and then allows it to issue into the combustion space 13. This measure conformable to the present invention renders it possible successfully to prevent the fuel from reaching the cooled walls of the housing 1 in liquid form, even where the radial dimension of the combustion space is very small.

Mixture formation then continues in the following manner:

Figure 2 shows the position at which the piston is located just before maximum com-

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pression. Two combustion spaces 13 and 16 are available by virtue of the trochoid shape. A violent movement of air occurs at the constriction 17 of the trochoid, since the air is forced out of the shrinking space 13 into the dilating space 16. The air is thereby forced partially to pass through the porous plate 10 according to the arrows 18, an intensive mixture formation thereby being caused with the fuel vaporised in the plate 10. A part of the fuel has emerged from the extremity 12 of the passage 11, and owing to centrifugal force also from the plate 10 in the area of the space 13, so that a mixture-forming action has also occurred in the space 13. The combustion can be initiated in the space 13 by means of the temperature due to compression or by means of an ignition device 19 which may be disposed therein, the movement of the masses of gas through the porous plate 10 or from the extremity 12 of the passage 11 being intensified thereby until the combustion travels into the space 16. The phenomena of flow at the constriction 17 can be influenced as desired by fitting a second ignition means 20, of which the ignition action takes place before, during or after that of the means 19 of ignition. By virtue of the further rotation of the piston, the mixture-forming gas flow acts on the entire length of the porous plate 10. The beginning and end of the peripheral extension of the plate 10 render it possible to perform an advantageous distribution of fuel in the entire elongated combustion space 13 and 16, and to control the required slow release of heat at will. By providing the flattening 21 of the plate 10, the flow velocities may also be varied locally and chronologically as desired, thereby preventing the occurrence of excessive internal losses caused by throttling. The extension of the porous plate in the direction towards the axis of the crankshaft may be made to differ in magnitude, in order to supply definite areas of the combustion space with more or less fuel. The conformation of the passage 11, referring to its radial and axial extension in particular, represents a useful expedient in attaining this goal.

Figures 3 and 4 illustrate other methods of supplying the fuel.

According to figure 3, the fuel is fed into the passage 11 beneath the porous plate 10 through a piston orifice 22, parallel to the axis of the crankshaft and not vertically. In the position illustrated, the peripheral speed of the sealing bar 3 sliding on the inner peripheral surface of the housing is at a minimum. This instant may preferably be utilised to feed the fuel into the passage 11 beneath the porous evaporation plate 10. In this case, the fuel is almost without pressure fed from the lateral opening in the sidewall of the housing and into the orifice 22. According to the rotational motion of the piston in the direction of the arrow 9, the fuel is then distributed beneath

the plate 10 in the manner previously described.

According to figure 4, the fuel is not fed in at the leading extremity of the plate 10 but at its middle. In this case, the nozzle 33 is disposed close to the constriction of the trochoid and the plate 10 exhibits an opening 23 through which the fuel can reach the passage 11. The distribution of the fuel in the passage 11 is assured by means of a prominence 24 protruding into said passage.

Figure 5 illustrates yet another modification in the method of fuel distribution. The section in this figure is taken parallel to the axis of the crankshaft through the piston. The passage 11 is in this case disposed in the actual rotary piston 2 and is given the form of a so-called "catching groove", so that the fuel which has been fed in according to the possibilities corresponding to figures 1, 3 or 4, is owing to the effect of piston rotation able to spread in the passage 11, but cannot escape from this groove under the action of centrifugal force, but collects in the spaces 25. When the transference occurs which has been described with reference to figure 2, the fuel is vaporised within the passage 11 by the compressed air entering at 26 and longitudinally traversing the passage 11, and is conveyed to the spaces 13 and 16 in the manner described with reference to figure 2. The opening 26 of the passage 11 may in this case be given the form of a continuous or discontinuous slot, or may be constituted by a number of circular connecting bores.

Depending on the desired axial distribution, the passage 11 according to figure 6 may exhibit lateral distribution bores 27, or it may according to figure 7 be subdivided into two or more passages, which may where appropriate also be fed from two different nozzles. Depending on the desired distribution effect of the fuel, the connecting bores leading to the spaces 13 and 16 may be given the form 28 or 29. The form of bore 28 predominates in the zones of greater fuel accumulation and where a later discharge of fuel is desirable, whereas the bores according to 29 are utilised in the zones in which fuel discharge is to occur first. By utilising these means, it becomes possible to produce a fuel distribution along the piston which corresponds to the distribution of the air and to the chronological desiderata regarding feed into these volumes of air.

The spatial dimensions have been exaggerated in the drawings in order to enhance clarity, as far as the passages are concerned. In respect of their practical embodiment, said passages may be machined into the rear side of a plate which is then inset into the piston top. The manner of fitting this plate provides the opportunity, by means of the size of the contact area with the part of the piston dissipating heat, of bringing the temperature to the

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values resulting in the highest speed of vaporisation for the fuels which are to be utilised.

WHAT WE CLAIM IS:—

1. A rotary piston internal combustion engine of the  $n$  and  $n+1$  lobe type having a piston eccentrically rotatable in a trochoidal shaped housing so as to define combustion spaces of varying volume within the housing, and in which fuel injected into passages formed in the piston passes through permeable barriers from the passages into the combustion spaces.

2. An engine as claimed in claim 1, in which some of the injected fuel is carried out of the passages into the combustion spaces by air flowing along the passages, without passing through the permeable barriers.

3. An engine as claimed in claim 1 or 2, characterised in that each barrier is a permeable plate and that the fuel is applied to the inner surface of this plate and is partly or wholly evaporated in a region of this plate and is supplied in this state to the air in the adjacent combustion space.

4. An engine as claimed in claim 3, in which the plate is porous.

5. An engine as claimed in claim 4, in which the plate is made of a sintered material.

6. An engine as claimed in claim 1, 2 or 3, in which each barrier has a number of holes or slots.

7. An engine as claimed in claim 3, in which the plate is made of a catalytically active metal or metal oxide, or possesses one or more locally distributed and catalytically active coatings, or is wholly or partly endowed with a ceramic coating or coating of metal oxide whereon are applied one or more catalytically active substances.

8. An engine as claimed in claim 3, in which the plate is mounted in the piston in a thermally insulated manner by restricting its contact area to a small surface or by means of the interposition of an insulating layer.

9. An engine as claimed in claim 3, in which the plate is made of ceramic material and is wholly or partly coated with a catalytically active substance.

10. An engine as claimed as claimed in any one of the preceding claims, in which each passage has an opening at its extremity which is trailing relative to the direction of rotation.

11. An engine as claimed in claim 1 or 2, in which each passage has a kidney-shaped cross-section, and the connecting openings leading to the combustion space in part open on to said passage in such manner, that the fuel acted upon by centrifugal force within the passage cannot flow off, or cannot more than partly flow off, through said openings.

12. An engine as claimed in claim 6, in which the holes or slots are distributed along the passage at identical or varying spacings.

13. An engine as claimed in claim 1 or 2,

in which each passage is milled into a plate which is secured to the piston.

14. An engine as claimed in any one of the preceding claims, in which an injection nozzle is incorporated in the trochoidal-shaped housing in the area of the constriction thereof, and injects fuel at such an angle relative to the direction of rotation of the piston, that the axis of the nozzle bore wholly or approximately corresponds in direction to that of a passage, the injection being controlled in such manner, that the opening located at the start of said passage runs past the nozzle bore during said injection.

15. An engine as claimed in any one of the preceding claims, in which at its extremity which is the leading one relative to the direction of rotation of the piston, said passage exhibits an opening in the direction towards a sidewall of the housing, and the injection sequence is controlled in such manner, that in the piston position in which the sealing bar is located at or near the constriction of the trochoid disposed on the combustion side, said opening is in alignment with a bore in the sidewall of said trochoid housing, through which bore the fuel is fed in at that instant.

16. An engine as claimed in any one of claims 1 to 13, in which a nozzle disposed in the trochoidal-shaped housing has an axis which simultaneously forms the jet axis and in its direction coincides with the shortest diameter of the trochoidal housing, and the injection is controlled in such manner, that shortly preceding the dead centre of compression, the bore of said nozzle is in alignment with another opening through which fuel issuing from the nozzle bore can penetrate into the appropriate passage.

17. An engine as claimed in any one of the preceding claims, in which the compression-ignition method is utilised, and where appropriate, readiness to ignite is assisted by utilising thermal means of ignition in the form of a hot point or a catalytically acting means of ignition, which is controlled as a function of temperature or load.

18. An engine as claimed in any one of the preceding claims, in which ignition occurs as a function of the operating condition either by means of a sparking plug or by means of spontaneous ignition.

19. An engine as claimed in any one of the preceding claims, in which two means of ignition of optional nature are fitted, which are disposed in the combustion spaces and which are made to operate at the same time or with an interval of optional duration.

20. An engine as claimed in any one of the preceding claims, in which a nozzle bore is drilled into the actual housing.

21. An engine as claimed in any one of the preceding claims, in which a nozzle bore is disposed in a zone of the trochoidal-shaped

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housing in which the pressure differential at the sealing bar is at its minimum.

22. Rotary piston internal combustion engines, substantially as hereinbefore described  
5 and as illustrated in the accompanying drawings.

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Chartered Patent Agents,  
Agents for the Applicant(s).

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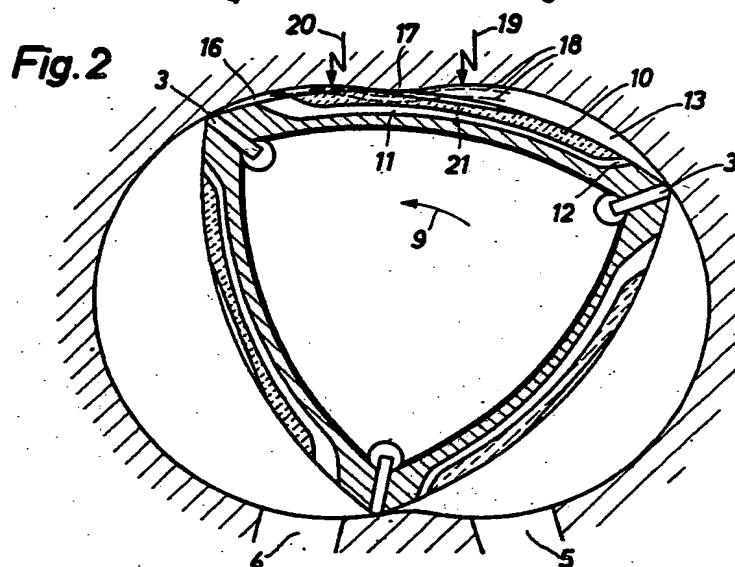
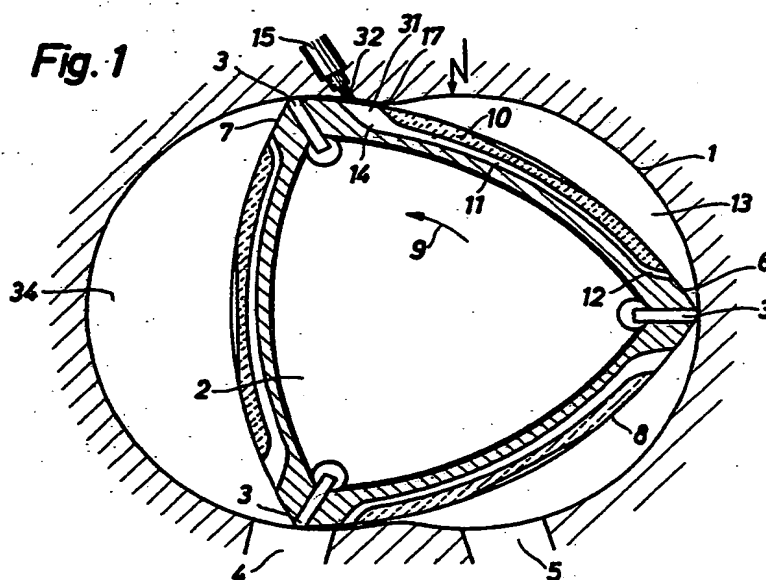
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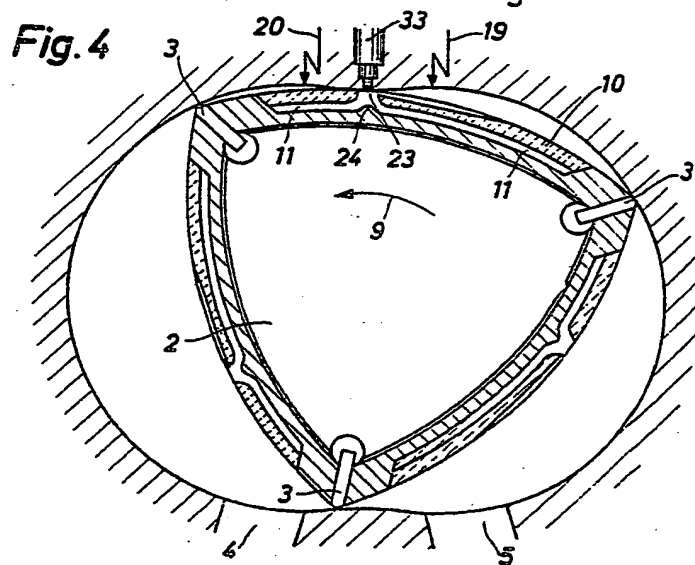
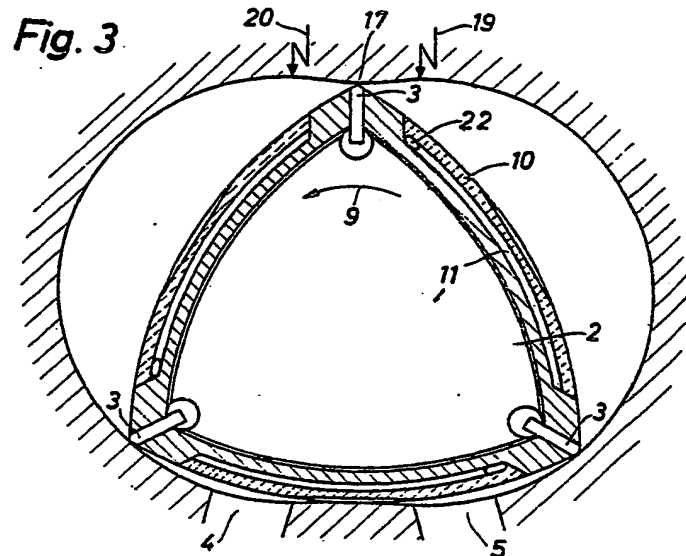
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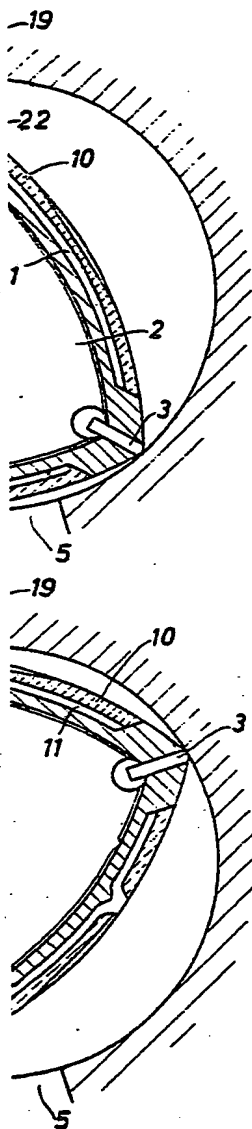


Fig. 5

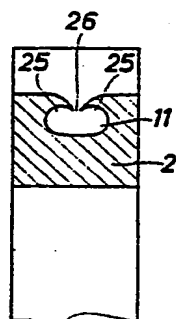


Fig. 6

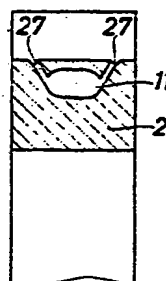


Fig. 7

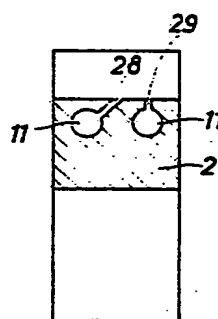
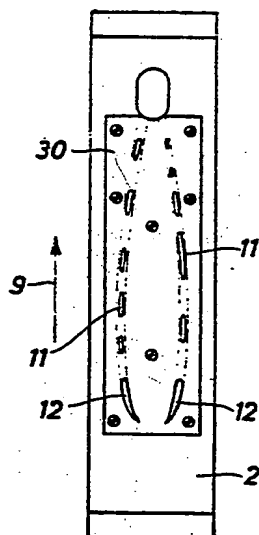
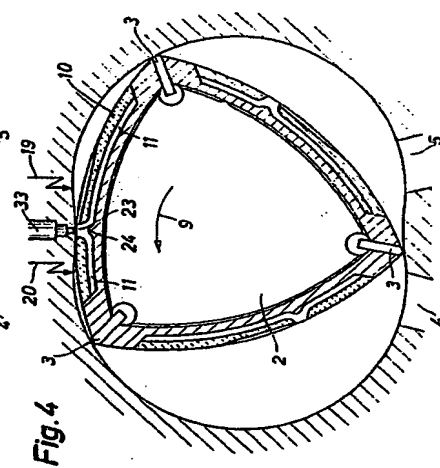
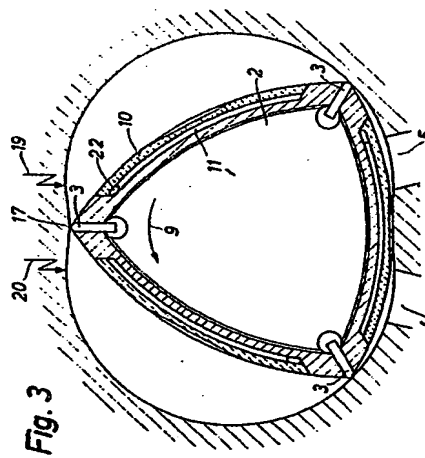


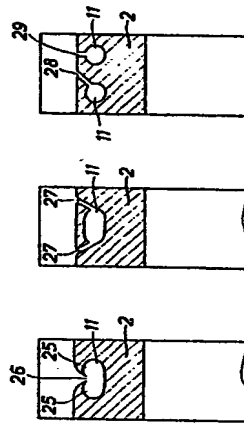
Fig. 8



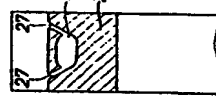
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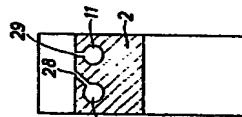
**Fig. 5**



**Fig. 6**



**Fig. 7**



**Fig. 8**

